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Flood damage estimate (quantity), using HEC-FDA model. Case study: the Neka river

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Abstract

The cost of damages due to flooding depends on several factors. However, several methods, using different approaches, can be used to estimate flood damages. In this study, the residential area of Neka river, in the East of Mazandaran province (north of Iran), is considered. The most important part of the river basin is the Neka city that is located in intersection of the foothills and coastal zone (Caspian Sea). According to Francou-Rodier Formula, this basin is potentially at the high risk of flooding. During past decades, several floods have been observed, resulting in costly property damages and human casualties. Therefore, flood damages need to be estimated basing on different scenarios, to be able to propose engineering optimized options for flood controls and to better manage the subsequent crisis. In this research, using GIS models, HEC-RAS, and HEC-GEORAS software, hydraulic conditions of flood were simulated and flood prone areas were determined for different return periods. Based on the output of this step, using HEC-FDA, a risk analysis was performed and flood damages were estimated quantitatively. Finally, the Expected Annual Damage (EAD)was obtained.

Keywords: Flood damage estimate, EAD, HEC-FDA, Neka river, Flood zone.

1. **Introduction**

Flood damage assessment is a very important issue which is considered in water engineering science. Flood

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damage assessment has a wide domain and depending on various factors can expect different results. In macro management level, the first step in defining the water engineering projects is economic analysis of projects. Thus, we can analyze and evaluate the feasibility phase of flood damages, and this can be the basis for planning for the study area. Although in many engineering projects it is sufficed to flood zone with specific return periods but by doing these types of studies, cost-benefit ratio of the different project is studied well and this causes the implementation of the projects which flood control will be its outcome.

In many cases flood damage estimation will be difficult and following many errors. Uncertainties of hydrologic, hydraulic, economic, social and multiplies errors of this estimations. In some cases, the severity of damage caused by flooding is much higher than previously estimated. Thus, economic studies of flood and comparing flood control projects need to select indicators for assessing their flood damage. Whole estimation of flood damage is difficult and impossible and therefore each part of the damage is estimated by classifying flood damage to its constituent parts in term of need.

Quantitative evaluation of flood damage is done in different ways. One of these methods is software modeling of flood damage analysis HEC-FDA. This model was developed by the U.S. Army Corps of Engineers and is acceptable for international resources. Based on hydraulic and hydrologic data of the study area, we can calculate the expected annual losses EAD by this way. A point that should be noted is that this model can estimate the economic amount of flood damage and flood damage assessment index is flood depth.

And then we introduce Neka river basin and flood damage in urban areas of Neka river is estimated using HEC-FDA software.

2. Introducing The Study Area

Neka River Basin, located in the extreme East of Mazandaran province. East coordinates between: (735394-705394) & (4064954-4034954) north latitude. Unlike the most major rivers of the area, Neka river which its main valley is east west area, Eighty percent of the catchment is covered by forest and the rest are covered by grasslands. The river originates from Shah Kooh heights located in the southwestern province of Golestan province and enter into the plains with a distance of about 160 kilometers and nearly 15 branches will be added to it the in this course. Neka river drainage area is approximately 2004 km^2. Length of 130 km, with average width of about 14.8 km and longitudinal steep of Neka river River is %1.9. The main part of the river is Neka the city which is located in the confluence of the mountainous part and coastal areas of caspian Sea. Neka river twist is high from the beginning and the bed slope is an average of %1. By closing the river to the Neka city the river twits are increasing gradually and finally it deformes river system so that the city of Neka in the surrounding of Neka river river has been developed (figure 1).

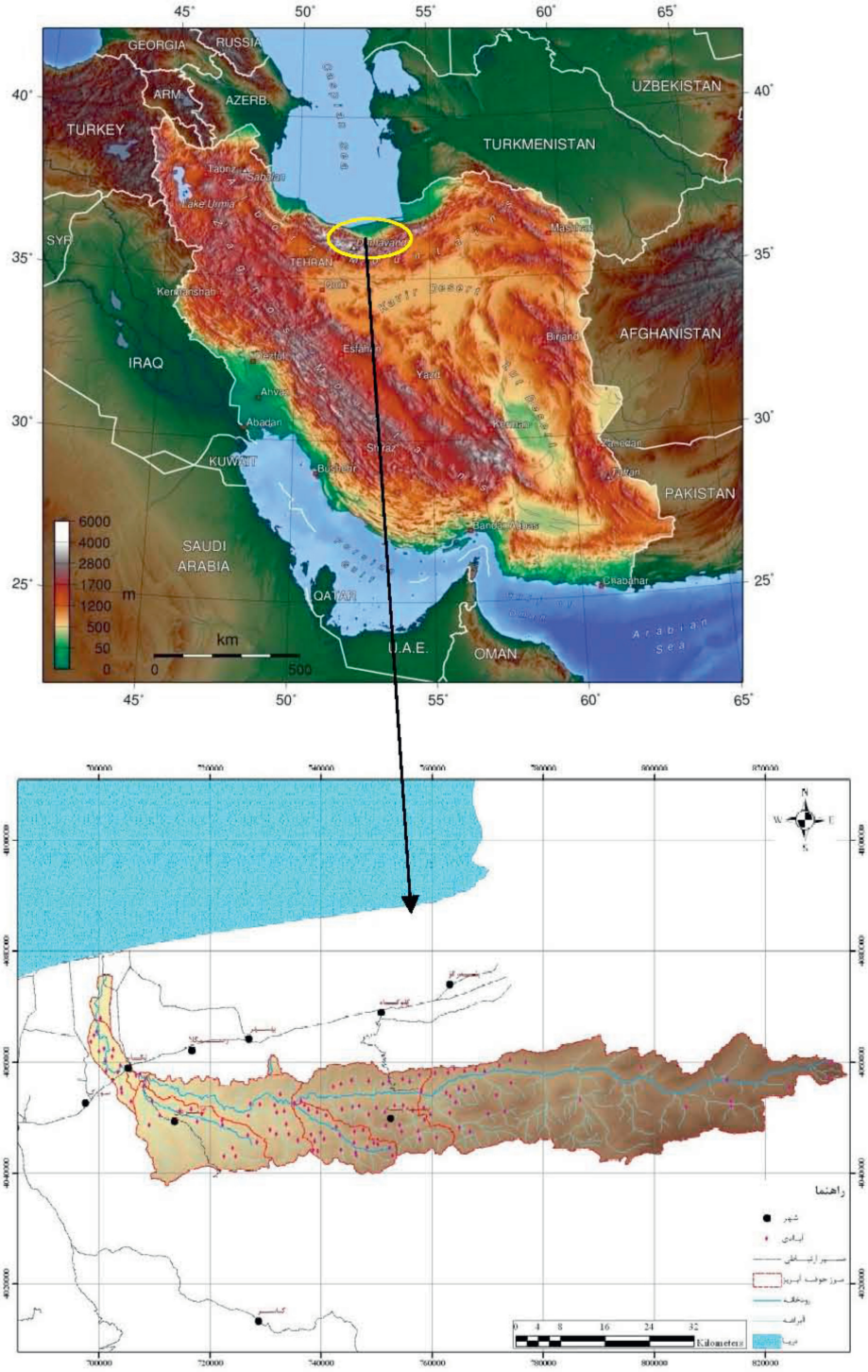


Fig. 1. The Map of the Neka River basin

3. Methodology of This Research

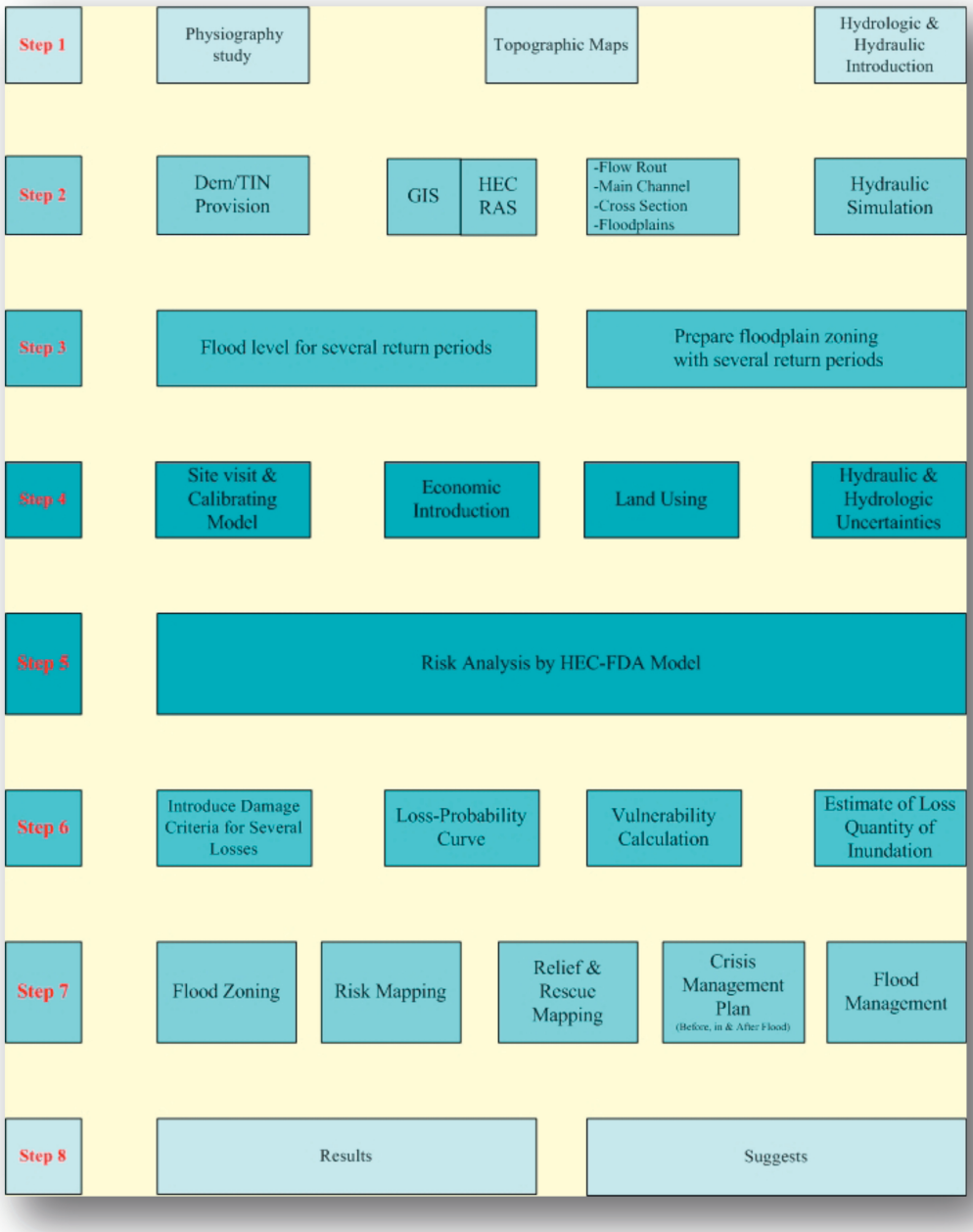


Fig. 2. The proposed process

4. Hydraulic Flow Simulation

First in GIS software, using digital map (1/2000), we get the TIN model of the study area. Then considering the flow of the river, cross sections, the axis of the river, the river band, and the edge of the river and flow path will be drawn.

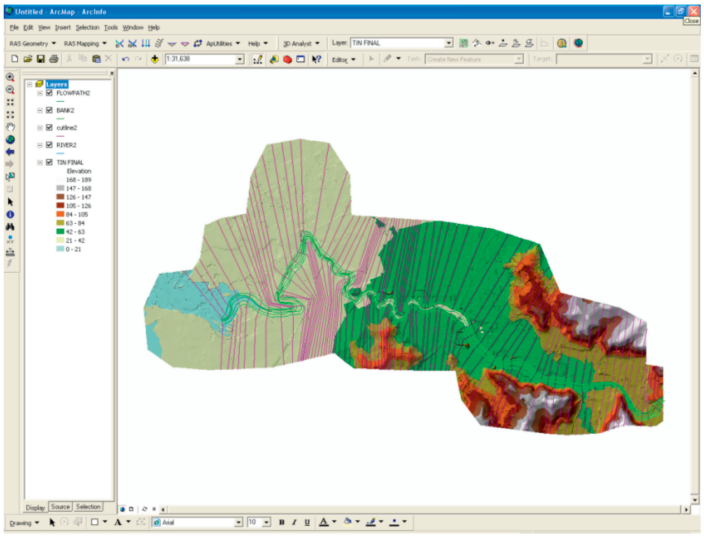


Fig. 3. Overview of the study area (GIS)

Then in HEC-RAS model, using thirty years statistical data of the study area, flood discharges for different return periods 2, 5, 10, 20, 25, 50, 100, 200 years is calculated. Manning roughness coefficient is obtained according to hydraulic studies, field visits and also by using Cowen method for different intervals. Boundary conditions of the model are taking into account considering the upstream and downstream slopes of the study area. Finally the model is implemented for the return period. (The output of this model will be used as input to the HEC-FDA model).

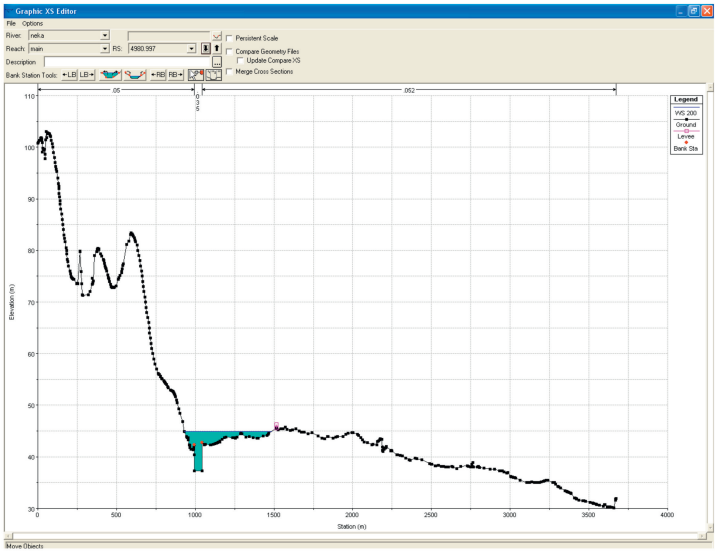


Fig. 4. Section of Neka river , reach number : 4980.997 (HEC-RAS)

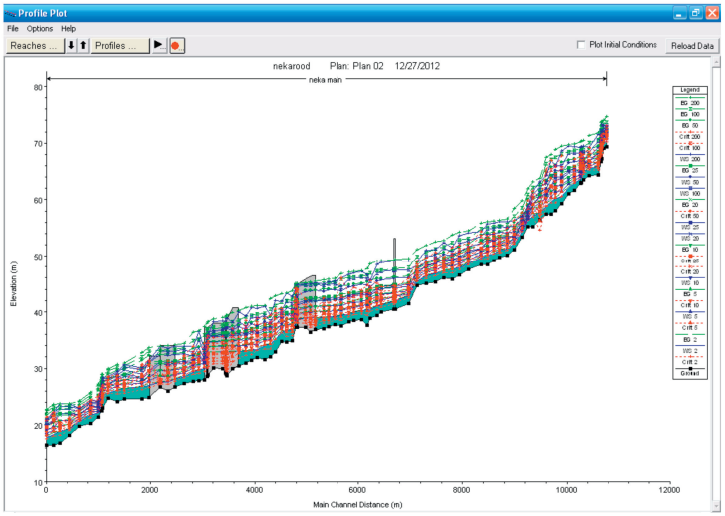


Fig. 5. profile of Neka river (HEC-RAS)

To obtain maps of flood zoning, according to earlier performed stages we can obtain flood zoning map in HEC-GEORAS software, for any return period and compare these flood zoning in GIS. This model can be used in google earth with respect to available using which its sample is presented in figure 6.

Fig. 6. Flood Mapping (200 Year), in neka urban area (Google Earth)

5. Quantitative Estimation of Neka river Flood Damage, Using HEC-FDA Model

The assessment of flood damage in the metropolitan area of Neka river, existing structures in the flow direction is considered in the model. In other words, the model is run for existing conditions. Coming up we divide the desired area into six intervals and residential, commercial, industrial, public, park and agricultural using are considered for each interval. Then hydraulic and hydrological data of the flow is entered for return periods of 2, 5, 10, 20, 25, 50, 100, 200 years (figure 7). Thus, using the HEC-RAS model output is stored in the FDA format, HEC-FDA model is used as input. Namely flood-depth values are considered for different sections. This is done for all considered intervals. Considering the input data to the model, the next steps are automatically calculated and it gives flow charts possibility based on thirty years statistical data for different intervals.

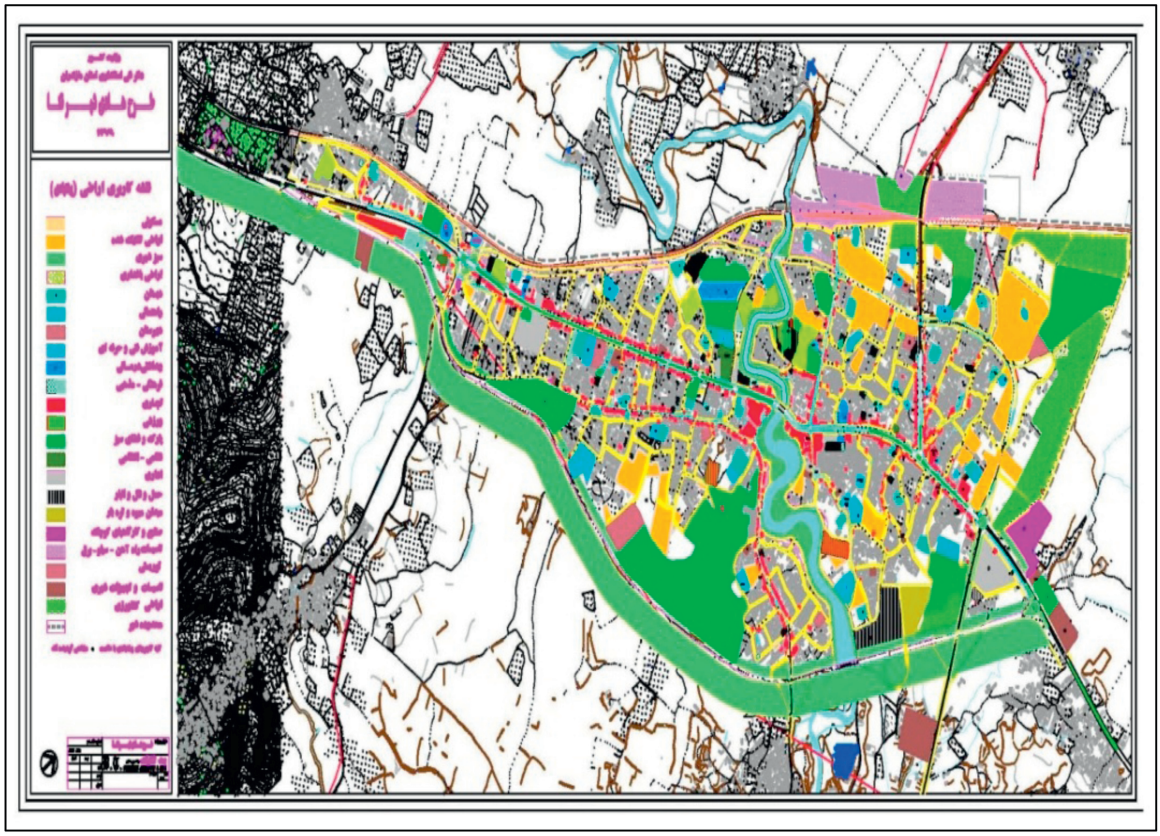


Fig. 7. Map of land using of Neka river urban area

For different land uses it should be considered level damage curve appropriate to it. There are many depth damage curves which Dutta et al. (2003) depth- damage curve is used here as presented in figure 8.

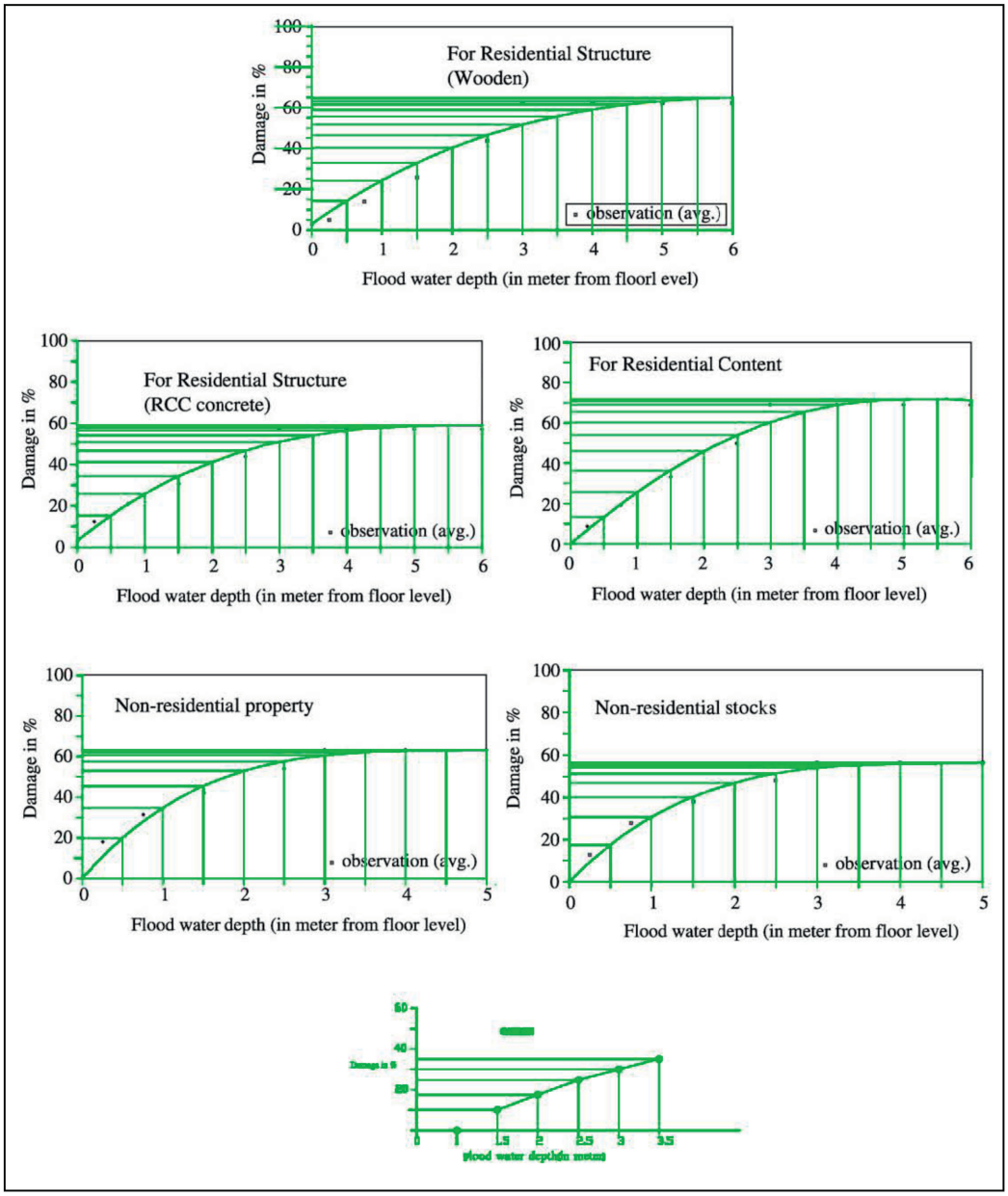
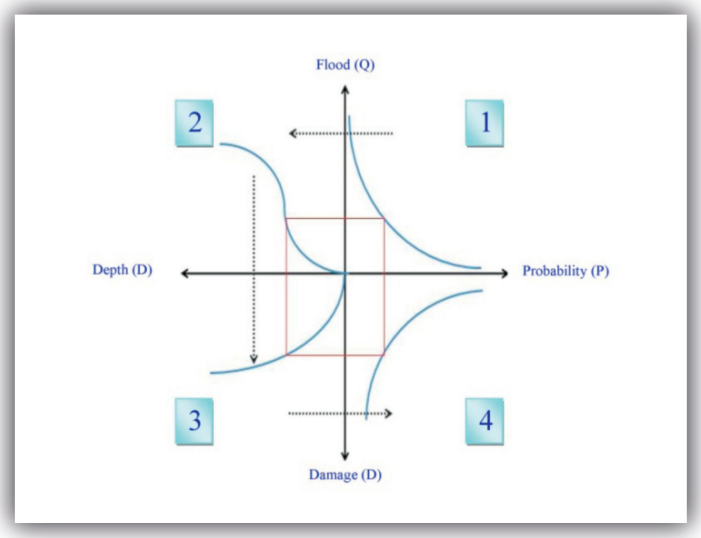


Fig. 8. Diagram of Damage–Depth, for Residential & non Residential land using

Finally the quantitative estimation of Neka river Rive damage, in urban area of Neka, is implemented based on the defined interval. The important point is that the basic action of this model is using Monte Carlo methods. Hydrologic and hydraulic data and the likelihood of recurrence for each different return period on one hand and high repetition of it on the other hand causes to decrease significantly the error rate for an interval by multiple repeating of it to reach the optimal level. In other words, uncertainties related to the model using Monte Carlo method are considered and runs at optimal levels, and finally causes to decrease the standard error which is presented in Figure 9.



$$EAD = \int_0^1 D_p dp$$

Fig. 9. Extraction of flood risk curve

Considering obtained data set which is mentioned above by running flood damage analysis model with HEC-FDA, the expected annual damage (EAD) over the entire studied interval which is in fact the sum of expected annual damages in six periods, as follows: EAD: 3.076.105.000 Rails (Table 1).

Table 1. Expected Annual Damage (HEC-FDA)

neka fda
Expected Annual Damage by Analysis Years for Without (Without pr
(Damage in $1,000's)

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Base Year 2013	Most Likely Future 2045
nekarood		drch1		70379.29	70379.29
		drch2		83100.31	83100.31
		drch3		49142.86	49142.86
		drch4		32234.76	32234.76
		drch5		58824.15	58824.15
		drch6		13929.12	13929.12
	Total for stream: nekarood			307610.50	307610.50

6. Results

Flood damage assessment process includes several studies that different conclusions can be taken from it. According to definition of projects (In the field of water and flood control engineering), One of the main criteria is Economic justification of the project. Although according to several uncertainties, accurate determination of economic estimates is not possible, but it is possible to get closer estimation to the exact amount of damage by several methods and do the analysis based on this result. Therefore it is expected that those results are applicable in top management accordingly. In the other word, in first step, the results of this research can be applied in top discussion of project definition. Fortunately, the results of this research are applicable continuously. The main conclusion that can be derived from this study is the expected annual damage (EAD). EAD= 3.076.105.000 Rails
Another result of this research is using of quantity result of flood damage assessment in flood insurance. This subject is suitable method for flood disaster management. Then, we can obtain hazard mapping using risk analysis doctrine & flood zoning. After that we can provide relief & rescue map of area. Finally, we can offer the planning of flood disaster management based of this information.

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